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ABSTRACT

This issue of Carnegie Quarterly focuses on a middle grades life science project in which students work together in groups to explore the properties of DNA. The project, entitled HumBio, was developed to capture young people's interest in science by promoting an understanding of their own biology so they can see how their health and well-being are influenced by their genes, their bodily functions, their family, the larger cultural and physical environment, and their own behavior. The article describes this program, its origins, middle school reform, design of the program, and dealing with potential controversy. Includes a list of 12 HumBio test site middle schools. (MKR)

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YOUR BODY, YOUR LIFE

Human Biology for the Middle Grades

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IN A UNIT ON genetics, sixth-grade students in Angie Williams' science class at Wakulla Middle School in rural Crawfordville, Florida, are getting ready to explore the properties of DNA, the genetic material that contains all the information needed to create life. Most of the students have heard about DNA from television science programs and newspaper articles or in science class during elementary school, but they have never had the opportunity to see it and touch it with their own hands.

Working together in groups, the students follow laboratory procedures and record observations much the way research biologists do. They work with test tubes containing herring DNA suspended in a simple salt solution. Layering the alcohol on top of the solution, they insert a glass rod into the tube and begin to stir it gently. Soon the DNA precipitates and wraps around the glass rod as a viscous gel, an action called "spooling."

At first it is daunting for them to think of this slimy clear gel as the substance of heredity. The surprise of how DNA actually looks soon gives way to discussion about its biological importance and explorations by the students about its physical properties: how it feels and smells and what it looks like under a microscope.

The activity sheet of the students asks them why it is important to study and understand DNA. It also asks them to design a follow-up activity using their isolated DNA. Angie Williams invites them to describe their observations and share their questions about DNA with their classmates. She then talks about a genetic disease called cystic fibrosis (CF), which, among other symptoms, causes thick, sticky mucus to build up in the lungs of children and young adults afflicted with the often fatal disease.

She tells her students that it is the presence of DNA in the mucus of CF patients that makes it thick and sticky, rather like the DNA in their test tubes. She describes an enzyme called DNase that breaks DNA apart. Scientists, she says, have found that when DNase is given to CF patients, the mucus lining in their lungs becomes much less thick and sticky, which helps them to cough it up and breathe more easily.

Ms. Williams takes a test tube with spooled herring DNA. She mixes in several solutions, then adds DNase and hands it to the students. They watch over several minutes as the DNA solution turns from a viscous mix to a liquid. The students have the opportunity to perform this procedure with their spooled DNA and to think more about its implications for the health of CF patients.

The Middle Grades Life Sciences Project

At Wakulla Middle School, students ages twelve to fourteen are learning about biological processes in a new curriculum in the life sciences, called HumBio. HumBio began seven years ago as an endeavor of leading scientists and educators at Stanford University, working in concert with middle school science teachers to change the way middle school science is taught. Its aims are to capture young people's interest in science, by promoting an understanding of their own biology so they can see how their health and well-being are influenced by their genes, their bodily functions, their family, the larger cultural and physical environment, and their own behavior.

The two-year curriculum is based on the premise that young adolescents, who are themselves undergoing the dramatic biological, psychological, and social changes of puberty, will be more motivated to learn science if it is relevant to their lives.

In HumBio, students do not merely read about human biology, they perform experiments, take part in group activities, carry out projects on topics reflecting their interests, concerns, and experiences, and debate issues with classmates. They study the biological characteristics that make each human being unique — for instance, by examining their own fingerprints. They learn the effects of drugs on the nervous system. They learn about their place in the history of life and in the biological world. And they discuss issues of peer pressure and family conflict.

HumBio, in short, deals not only with scientific facts and processes, it

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encourages students to think through the health, ethical, and social dimensions of what they learn. "By combining science and technology with health, social, and ethical considerations, many different points of view are expressed," explains Mary L. Kiely, director of Stanford's Middle Grades Life Sciences Curriculum Project, which is developing HumBio. "And students come to realize that science, contrary to what many have come to expect, is not detached from everyday life."

"Adolescents," comments H. Craig Heller, a Stanford biology professor and principal investigator of the middle grades curriculum project, "are very much aware of the changes taking place in their own bodies, but they tend to regard what the schools traditionally teach about biology at that stage as irrelevant and boring. There is no reason why this should be so. Why not make science come alive? And why not make it accessible to all students?

"Young people," he adds, "should not get the message that science is an elitist activity for strange men and women in white coats. Everyone must learn about science, and we should because it influences us every day of our lives."

These are exactly the principles underlying the HumBio curriculum, which has been tested and evaluated over the past four years in twelve diverse middle schools across the country.

HumBio's Origins

The inspiration for HumBio was actually a college-level major, Stanford's undergraduate Program in Human Biology, which was created in the 1960s by a group of faculty members representing a range of scientific disciplines. The idea was to offer a unique interdisciplinary major linking the biological and behavioral sciences — one that would attract liberal arts as well as science students. The program has evolved into one of Stanford's most popular undergraduate programs.

The middle grades project grew out of a set of concerns of science educators, informed members of the public, and specialists on adolescent development. Among them was David A. Hamburg, president of Carnegie Corporation and a cofounder of Stanford's undergraduate human biology program when he chaired the department of psychiatry and behavioral sciences at Stanford's School of Medicine. One concern was over the watered-down, vocabulary-laden life science curriculum that was, and still is, typical of many middle school science offerings — what Heller dubs the "tiptoeing through the phylae approach." In this regime, modeled on high school biology, students are required to memorize scientific terms, often without an elucidation of their meaning or of their relevance to adolescents' experiences. "These programs are about as exciting as counting the number of legs on a grasshopper," wryly observes Heller.

It is in this kind of science course that many middle grade students experience their first bitter taste of academic failure and begin to think of dropping out of school or, at best, avoiding all exposure to science for the rest of their lives. Heller believes, however, that, "If you don't acquire scientific curiosity in the middle grades, you are not likely to get it at all." That is why he and his colleague Herant Katchadourian, professor of psychiatry and behavioral science at Stanford, who teaches in the undergraduate human biology program, started researching and planning the middle grades project in 1987.

Another concern of the scientists and educators was over the large and increasing numbers of adolescents who are experimenting with unhealthy behaviors, such as drinking alcohol, smoking cigarettes, using illegal drugs, and engaging in early sexual activity — behaviors that are often aggravated by academic underachievement, especially in math and science. By giving students a knowledge of their own bodies, so they can understand for themselves the consequences of risky behaviors, the creators of HumBio believed young people might become more motivated to safeguard their health and well-being and make more informed decisions over their lifetime.

As a physician and scientist interested in the major physiological and behavioral transitions of childhood and youth, Hamburg believed that a rigorous middle grades life

> "The goal of HumBio is to accomplish four changes: teach better and more exciting science; integrate the natural and behavioral sciences; make science relevant to children's lives; and let science teach them how to avoid risky behavior." — Herant Katchadourian

sciences curriculum, focused on human biology — and where possible on the adolescent — could greatly improve core curricula in science at this level and in the process hook students into science. "HumBio is designed to appeal to young people's emerging curiosity about themselves and the changes taking places within them. They are already asking, 'What's happening to my body? How does the human body work, anyway?'" Ultimately, thought Hamburg, such a course could provide students opportunities to apply their new knowledge of biology to their health and to the broader challenges they face as adolescents. "I see study of the life sciences as a fundamental human quest and a pathway to the other sciences."

The HumBio project represents a conjunction of several significant Carnegie Corporation interests: the entire span of science education; improved education for disadvantaged students; and early adolescence. For Hamburg, the middle grade period is an especially important time to reach disadvantaged children, both to keep them from losing interest in science and to deliver vital messages about their health.

As Katchadourian summarizes it, HumBio's goal is "to accomplish four changes: teach better and more exciting science; integrate the natural and behavioral sciences; make science relevant to children's lives; and let science teach them how to avoid risky behavior."

From 1987 through June of 1990, the curriculum project's research and development phase was funded entirely by the Corporation. In July 1990, the project received additional substantial funding from the National Science Foundation for the development of the science units and the training of teachers, a crucial element of this program. Kiely, a biology Ph.D. with extensive experience in science and health policy, has managed the project since 1990.

HumBio and Middle School Reform

In too many junior high schools, and in some middle schools still, there is a departmental rigidity that discourages the coordination of courses across the disciplines and prevents students from discovering the connectedness of the different branches of knowledge. In the mid-1980s, however, organizational changes toward interdisciplinary learning, team teaching, and team planning began to get under way in the middle grades. These changes gained national momentum with the release of *Turning Points: Preparing Youth for the 21st Century*, in 1989. Sponsored by the Carnegie Council on Adolescent Development and Carnegie Corporation, this report underscored the drastic mismatch between the organization and curricula of most middle schools or junior high schools and the intellectual, emotional, and interpersonal needs of young adolescents.

The report proposed a set of high-aspiration but not utopian reforms for

the middle grades. The new schools should be broken down from large impersonal institutions housing thousands of students into smaller teaching units involving students who would learn together over the two- to three-year period of middle and junior high school. Classrooms would be staffed by teachers specially trained to deal with young adolescents. They would offer interdisciplinary curricula that would provide the information, skills, and reasons for adolescents to learn about themselves and their widening world. They would foster a mutual-aid ethic between teachers and students, through team teaching, cooperative learning that de-emphasizes tracking, and academically supervised community service.

Turning Points' recommendations reinforced the emerging movement to create developmentally appropriate schools for young adolescents and to strengthen their education through new linkages among schools, families, communities, and health care institutions.

The core recommendations of the report are now being extensively implemented in fifteen states and 175 schools (and still growing) throughout the United States and the Commonwealth of Puerto Rico, under a program supported by the Corporation called the Middle Grade School State Policy Initiative (MGSSPI).

The same year that *Turning Points* was published, the first se. of recommendations of what a scientifically literate high school graduate should know and be able to do was published in *Science for All Americans*, prepared by Project 2061 of the American Association for the Advancement of Science, also Corporation supported. Contained in this report were recommendations for a new approach to the study of living organisms and life processes covered at the middle level — one that would promote more in-depth, inquiry-based learning and give more emphasis to hands-on science activities and to making connections.

In 1990, a high-level committee of biologists and educators was also convened by the National Research Council of the National Academy of Sciences. In its report, *Fulfilling the Promise: Biology Education in the Nation's Schools* (National Academy Press), the committee concluded that biology, the first formal science experience for most public school students, was taught so poorly that it "seems designed to snuff out interest at an early age in learning about any kind of science."

The committee highlighted a recommendation that middle school biology be geared toward adolescents' natural curiosity about their health and their bodies. Then the National Middle School Association (NMSA), based in Columbus, Ohio, released its initial position paper, *The Middle Level Curriculum*, in 1993. In that paper the NMSA strongly supported "learning experiences that help young adolescents make sense of themselves and the world around them, and actively engage students in problem solving and a variety of experimental learning opportunities."

The changes urged by these prestigious groups fit perfectly with the ideas and philosophy of Stanford's middle grade life sciences project. What began with David Hamburg's vision, therefore, was shaped by the expertise of two strong content faculties at Stanford — education and the human biology program — and eventually became part of the leading edge of science and middle grade education reform.

Design of the Program

"HumBio," says Heller, "asks the student, 'Who are you?' and responds clearly, 'You are special.' It helps young adolescents recognize the similarities that exist among and between people and teaches them to focus on themselves in relation to others and their environment."

The entire two-year curriculum is projected to have twenty-two units, or modules, that can be used in any combination or order, at the school's or the teacher's discretion. Each unit is designed to take about three weeks of classroom time, which may be extended through a variety of activities and projects.

Six units of the HumBio series concentrate on the social aspects of adolescent development. They present information on changes during puberty and aspects of human sexuality and reproduction. These units introduce activities that help students express their concerns about adolescence and think through the ethical and other dimensions of various choices they might make in their own lives. Others cover evolution and ecology, genetics, the nervous system, cell and developmental biology, the circulatory system, breathing, digestion, nutrition, and the immune system. Still others explore the young person's relationships to family, school, community, and the larger world.

The units are rich in hands-on activities. In genetics, groups of students are encouraged to design and present a genetic engineering project. They focus on the problem of making ethical choices as well as the technological aspects. Should genetic engineering be used to cure genetic diseases? Should money and effort be spent on developing a human youth hormone to keep people looking and feeling young? Should a gene for being slender or for being tall be inserted into a person's genetic makeup?

Teachers who are involved in testing the curriculum report that such questions overturn misconceptions that students often bring into the classroom and provoke them to think about making personal choices based on solid scientific knowledge.

The lessons are not limited to the science classroom but are extended across the entire middle grades curriculum into mathematics, social studies, language arts, and often physical education and health. Teams of teach-

ers from each of these disciplines are working together to agree on how they can build subject matter from the different curricular units into their respective classes. Mathematics teachers, for example, may contribute an understanding of the data collected in a science experiment through the use of charts, graphs, and other mathematical concepts and connections. English teachers may ask students to develop a creative writing piece on how science affects their lives using examples from the HumBio activities, or encourage them to read books related to what they have observed in science. Social studies teachers may deal with the impact of biological and other scientific developments on the development of technology.

"Teaming at the middle level means that a group of teachers across subjects share the same students," explains Kiely. "Their students rotate through the individual classes throughout the day, but the teachers are able to collaborate and make connections among the subjects because they work together on presenting the overall middle-level curriculum to a particular group of students."

Teachers have been included as full partners in the development of the curriculum. In the summer institutes at Stanford, HumBio teachers helped to shape many of the ideas that have been incorporated into the materials. They favored the development of a series of units rather than a textbook on human biology. They suggested that the units contain an abundance of hands-on activities that would allow students to engage in the process of scientific investigation. They advocated improved access to the materials for all students through group work activities. And they urged making direct connections between the science presented and the health and well-being of the student. Once they returned to their schools where these ideas were tested against the realities of the classroom, their experience was fed back into the curriculum development process, in some cases resulting in substantial modification of the materials.

Dealing with Potential Controversy

The designers of HumBio have long recognized the potential for controversy that lies in teaching young people how the human body works. This is particularly true of the units that deal with pubertal processes, reproduction, and sexuality, but also of evolution. As early as 1989, in the program's planning stage, Hamburg pointed to the problems likely to be encountered: "You can't teach biology without seriously considering sex and evolution. This can be done in a way that is factually accurate and respectful of different views in a democratic society." He counseled that, rather than avoid controversy, the designers of the human biology curriculum should "go ahead and deal constructively with what good science demands," leaving it to communities to make their choices.

"Individual schools," Hamburg noted further, "will have to decide what is appropriate for each community, and the publication of separate units makes that decision easier. Some units may be skipped without jeopardizing the entire program." Interestingly, in the test sites, the unit that discusses evolution has turned out to be more sensitive within certain communities than the units dealing on human sexuality, because many schools already have courses on human health or life sciences that cover sexuality and reproduction.

Diverse Test Sites

In the meantime, the HumBio curriculum continues to be used in the twelve test site middle schools that have been working with HumBio staff. The schools, located in nine states across the country, were selected because they are already considered good examples of their kind, having embraced the middle school philosophy and having strong committed teacher teams and generally strong support from the administration and parents. One of the schools, Picacho Middle School in Las Cruces, New Mexico, is also part of the MGSSPI project implementing the *Turning Points* recommendations.

"With the great diversity in student population, geographic location, and organization of the schools among the test sites, we were to identify which features of the curriculum worked well in all of these settings and which ones still needed work," says Heller.

In general, the test site teachers and students report that the hands-on activities and the applications to health, social, and environmental issues have been among the more successful aspects of the HumBio units. At Egan Intermediate School in Los Altos, California, HumBio is unlike any curriculum that has ever been tried, and the students are avidly taking to it. "I like the activities because you get to experience real-life situations in labs," says one student. "It helped me to understand about who I am," says another. "I liked doing the math growth charts and finding out how tall we will probably be," testifies a third.

Adequate in-service training in team teaching and in implementing a curriculum that is not textbook dependent is crucial. Those who have had the benefit of the summer institutes each year understand this.

As part of an evaluation study of the Human Biology Middle Grades Curriculum Project, Inverness Research Associates in Inverness, California, in May 1995 visited two test sites, East Lyme Middle School in Niantic, Connecticut, and Wakulla Middle School. According to the Inverness report, teachers, administrators, and other support personnel appear to view HumBio as a "very workable curriculum." It is "challenging but doable," and the units fit in with and extend existing curricula. Teachers

like the modular structure, because it allows them to pick and choose. They think the curriculum is age appropriate, providing a good balance and integration of social and personal matters.

Importantly, concluded the Inverness researchers, "Teachers felt that HumBio's emphasis on middle school students' lives did not mean sacrificing any vital science content, while students found the HumBio approach to this content helped make the curriculum enjoyable, meaningful, and memorable." Overall, the experience shows that controversial subjects "can be part of a curriculum and handled without difficulty."

Some teachers thought the curriculum, however, should include more long-term experiments or projects. All agreed that HumBio is not "teacher-proof." On the contrary, "it will require substantial in-service teacher preparation in order to make the curriculum work."

Whatever HumBio's growing pains, the first schools to have introduced the curriculum have given new life to the study of science. They are proving that science is a field of study in which all students can be involved and succeed. The last effort at reforming science education came in the late 1950s as a somewhat panicky response to the launching of Sputnik by the Soviet Union. But it was aimed largely at the high schools and at the elite achievers among the student body.

Today's reformers are convinced that adolescents in the middle grades are the ideal age group to be familiarized with science and, in particular, with the way the human body functions and how to use it wisely. Students who might ignore or even sneer at a lecture on DNA are far more likely to want to understand its biological importance after seeing it with their own eyes and thinking about its implications for their health. ■

— FRED M. HECHINGER
AND AVERY RUSSELL

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HumBio Test Site Middle Schools

1. Anson Jones Middle School, San Antonio, TX
2. Central Park East Secondary School, New York City, NY
3. Dozier Middle School, Newport News, VA
4. East Lyme Middle School, Niantic, CT
5. Egan Intermediate School, Los Altos, CA
6. Overland Trail Middle School, Overland Park, KS
7. Picacho Middle School, Las Cruces, NM
8. Ruffner Middle School, Norfolk, VA
9. St. Elizabeth Catholic School, Dallas, TX
10. South Oldham Middle School, Crestwood, KY
11. Wakulla Middle School, Crawfordville, FL
12. William H. Crocker Middle School, Hillsborough, CA

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CARNEGIE COUNCIL ON ADOLESCENT DEVELOPMENT

On October 12–13, 1995, the Carnegie Council on Adolescent Development issued its concluding report at a national meeting in Washington, D.C. Attending the meeting were some four hundred representatives of government, business, nonprofit organizations, the academy, and the media. The recommendations of the report have been widely reported in the press. The council will conclude its formal activities in June 1996.

Single copies of the 168-page report, *Great Transitions: Preparing Adolescents for a New Century*, are available for $10.00. To order a copy, send a check, payable to the council, to CCAD, P.O. Box 753, Waldorf, MD 20604. Bulk rates are available by calling the council at (202) 429-7979. All orders must be prepaid.

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In 1994 Carnegie Corporation established an informational node (or "gopher") on the Internet, containing the full text of selected Corporation publications. In August 1995 it added a "home page" on the World Wide Web, connected to the text-only gopher for cross-referencing. These are available by accessing either **gopher.carnegie.org or http://www.carnegie.org** on the World Wide Web.

A cover story in the December 1995 issue of *PC Computing* highlights the best 1,001 Internet sites. On page 135 the Corporation is listed as one of the best in the "Charities, Clubs, & Organizations" category.

STAFF NEWS

The Corporation's executive vice president, Barbara D. Finberg, was elected chair of Independent Sector at the organization's annual meeting on October 24, 1995. A coalition of 800 corporate, foundation, and voluntary organizations with national interest and impact in philanthropy and voluntary action, Independent Sector is a national forum that encourages giving, volunteering, and not-for-profit initiatives to serve people, communities, and the nation. It engages in research and public education about the not-for-profit sector, monitors government actions and represents the independent sector to government, encourages development of high-quality leadership and high ethical standards among members of the sector, and serves as a meeting ground for grantmakers and the voluntary sector. Former Carnegie Corporation president John W. Gardner, one of the principals who founded the organization in 1980, served as its first chair.

The Carnegie Commission on Preventing Deadly Conflict has three new senior staff members. John J. Stremlau, who was a consultant to the commission, is now advisor to the executive director. Earlier he served in the Bush and Clinton administrations as deputy director of the secretary of state's policy planning staff. Senior associate Esther Brimmer previously worked as a special assistant to the under secretary of state for political affairs. Senior associate Thomas J. Leney held several positions with the U.S. Department of the Army, most recently as chief, strategic plans and policy.

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